

## CLAIMS

1. A method for assessing adequacy of message flow testing, comprising:

defining coverage criteria for testing a message flow through a set of message flow elements;

determining a message-flow-coverage-goal for the message flow with respect to the coverage criteria;

designing a test suite responsive to the message-flow-coverage-goal;

applying the test suite to the message flow to generate a coverage result for the set of message flow elements; and

comparing the coverage result with the message-flow-coverage-goal.

2. A method according to claim 1, wherein the message flow comprises a message-oriented software program wherein a message is a primary architectural element.

3. A method according to claim 1, wherein the message flow is comprised in a message-oriented middleware application.

4. A method according to claim 1, wherein the message flow comprises a visual program describing processing logic as a directed graph and wherein the message flow comprises an independent function, outside of a message sender or message receiver.

5. A method according to claim 1, wherein the message flow comprises a program processing a message produced by an application chosen from one of a group of applications comprising a client application and a server application.

6. A method according to claim 5, wherein the

1  
2 application comprises a message-sending-application and a  
3 message-receiving-application executing on different  
4 hardware platforms.

1 7. A method according to claim 6, wherein the  
2 message-sending-application and the message-receiving-  
3 application are implemented using different software and  
4 architectural paradigms.

1 8. A method according to claim 1, wherein the  
2 message flow elements comprise at least one element  
3 chosen from messages, nodes, connections, terminals,  
4 statements, conditions, external resources, and  
5 exceptions.

1 9. A method according to claim 1, wherein defining  
2 the coverage criteria comprises selecting a coverage  
3 model from at least one of processing node coverage,  
4 terminal coverage, connection coverage, path coverage, N-  
5 node coverage, statement coverage, multiple condition  
6 coverage, exception coverage, external resources  
7 coverage, and message content coverage.

1 10. A method according to claim 1, wherein  
2 determining the message-flow-coverage-goal comprises  
3 establishing a required coverage level for at least one  
4 of the coverage criteria.

1 11. A method according to claim 1, wherein applying  
2 the test suite to the message flow comprises:

3 performing an execution of at least a part of the  
4 test suite; and

5 evaluating an attained coverage level resulting from  
6 the execution.

1 12. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 visiting one or more nodes during the execution of

4 the at least part of the test suite;  
5 comparing a number of processing nodes visited to a  
6 total number of all processing nodes in the message flow;  
7 and  
8 computing a processing node coverage metric  
9 responsive to the comparison.

1 13. A method according to claim 12, wherein  
2 visiting the one or more nodes comprises entering a  
3 simple node.

1 14. A method according to claim 12, wherein  
2 visiting the one or more nodes comprises entering a  
3 compound node and visiting zero or more nodes in a  
4 constituent sub-flow.

1 15. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 traversing one or more terminals during the  
4 execution of the at least part of the test suite;

5 comparing a number of processing node terminals  
6 traversed to a total number of processing node terminals  
7 in the message flow; and

8 computing a terminal coverage metric responsive to  
9 the comparison.

1 16. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 traversing one or more connections during the  
4 execution of the at least part of the test suite;

5 comparing a number of connections traversed to a  
6 total number of connections in the message flow; and

7 computing a connection coverage metric responsive to  
8 the comparison.

1 17. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 selecting a group of one or more sets of N-nodes  
4 from the message flow, wherein N comprises any whole  
5 number less than or equal to a total number of nodes in  
6 the message flow;

7 performing at least one execution of the message  
8 flow so as to determine a number of nodes visited in each  
9 of the one or more sets during the at least one  
10 execution;

11 generating a respective set coverage result for each  
12 of the one or more sets, responsive to the number of  
13 nodes visited;

14 determining a number of covered-sets, responsive to  
15 the set coverage results;

16 comparing the number of covered-sets to a total  
17 number of sets in the group; and

18 computing an N-node coverage metric responsive to  
19 the comparison.

1 18. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 performing zero or more runtime exceptions during  
4 the execution of the at least part of the test suite;

5 comparing a number of runtime exceptions performed  
6 to a total number of all runtime exceptions in the  
7 message flow; and

8 computing an exception coverage metric responsive to  
9 the comparison.

1 19. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3 visiting zero or more failure terminals during the  
4 execution of the at least part of the test suite;

5 comparing a number of failure terminals visited to a  
6 total number of all failure terminals in the message  
7 flow; and

8       computing an exception coverage metric responsive to  
9       the comparison.

1       20. A method according to claim 11, wherein  
2       evaluating the attained coverage level comprises:

3       executing zero or more node statements at least once  
4       during the execution of the at least part of the test  
5       suite;

6       comparing a number of node statements executed to a  
7       total number of node statements in the message flow; and

8       computing a statement coverage metric responsive to  
9       the comparison.

1       21. A method according to claim 20, wherein  
2       computing the statement coverage metric comprises  
3       comparing a number of node statements executed in a  
4       single node to a total number of node statements in the  
5       single node.

1       22. A method according to claim 20, wherein  
2       computing the statement coverage metric comprises  
3       comparing a number of node statements executed in a  
4       compound node's constituent sub-flows to a total number  
5       of node statements in the compound node's constituent  
6       sub-flows.

1       23. A method according to claim 11, wherein  
2       evaluating the attained coverage level comprises:

3       assessing an achievement of true and false values  
4       for each of zero or more boolean sub-expressions  
5       independently during the execution of the at least part  
6       of the test suite;

7       comparing the achievement for the one or more  
8       boolean sub-expressions to a total number of boolean sub-  
9       expression values possible in the message flow; and

10       computing a multiple condition coverage metric  
11       responsive to the comparison.

12           24. A method according to claim 23, wherein  
13 computing the multiple condition coverage metric  
14 comprises comparing a number of achieved true and false  
15 values for zero or more boolean sub-expressions in a node  
16 to a total number of boolean sub-expression values  
17 possible in the node.

1           25. A method according to claim 23, wherein  
2 computing the multiple condition coverage metric  
3 comprises comparing a number of achieved true and false  
4 values for zero or more boolean sub-expressions in a  
5 compound node's constituent sub-flows to a total number  
6 of boolean sub-expression values possible in the compound  
7 node's constituent sub-flows.

1           26. A method according to claim 11, wherein  
2 evaluating the attained coverage level comprises:

3           assessing a number of values assumed by each of one  
4 or more fields in a message during the execution of the  
5 at least part of the test suite;

6           comparing the number of values assumed to a total  
7 number of possible values for each field in the message;  
8 and

9           computing a message content coverage metric  
10 responsive to the comparison.

1           27. A method according to claim 26, and comprising  
2 computing a strong message content coverage metric  
3 wherein the total number of values possible for each  
4 field in the message comprises a cross product of the  
5 message fields with their possible values.

1           28. A method according to claim 26, and comprising  
2 computing a weak message content coverage metric wherein  
3 the total number of values possible for each field in the  
4 message comprises a sum of the number of possible values  
5 for each message field independently.

29. A method according to claim 11, wherein evaluating the attained coverage level comprises:

traversing one or more paths during the execution of the at least part of the test suite;

comparing a number of paths traversed to a total number of paths in the message flow; and

computing a path coverage metric responsive to the comparison.

30. A method according to claim 11, wherein evaluating the attained coverage level comprises:

performing zero or more types of accesses to an external resource during the execution of the at least part of the test suite;

comparing a number of types of accesses performed to a total number of types of accesses in the message flow; and

computing a external resources coverage metric responsive to the comparison.

31. A method according to claim 1, wherein designing the test suite responsive to the message-flow-coverage-goal comprises:

identifying an initial test suite for the message flow;

assessing a coverage level achieved by the initial test suite; and

adding additional tests to the initial test suite so as to increase the coverage level.

32. A method according to claim 1, wherein applying the test suite comprises generating message-flow-coverage-reports.

33. A method according to claim 29, and comprising integrating the message-flow-coverage-reports into a

3 visual message flow development environment.

1 34. A method according to claim 1, and comprising  
2 reporting coverage graphically using at least one  
3 graphical element chosen from a set of color, shading,  
4 highlighting, graphing, fonts, line styles, icons, and  
5 labels.

1 35. A method according to claim 1, and comprising  
2 reporting coverage via at least one medium chosen from  
3 hard-copy media and electronic media.

1 36. A method according to claim 1, wherein  
2 generating the coverage result comprises collecting  
3 coverage data using at least one method of data  
4 collection chosen from message flow instrumentation and  
5 data logging.

1 37. Apparatus for assessing adequacy of message  
2 flow testing, comprising a computer system which is  
3 adapted to define coverage criteria for testing a message  
4 flow through a set of message flow elements, determine a  
5 message-flow-coverage-goal for the message flow with  
6 respect to the coverage criteria, design a test suite  
7 responsive to the message-flow-coverage-goal, apply the  
8 test suite to the message flow to generate a coverage  
9 result for the set of message flow elements, and compare  
10 the coverage result with the message-flow-coverage-goal.

1 38. A computer software product for assessing  
2 adequacy of message flow testing, comprising a computer-  
3 readable medium having computer program instructions  
4 recorded therein, which instructions, when read by a  
5 computer, cause the computer to define coverage criteria  
6 for testing a message flow through a set of message flow  
7 elements, determine a message-flow-coverage-goal for the  
8 message flow with respect to the coverage criteria,



9 design a test suite responsive to the message-flow-  
10 coverage-goal, apply the test suite to the message flow  
11 to generate a coverage result for the set of message flow  
12 elements, and compare the coverage result with the  
13 message-flow-coverage-goal.

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